

Real-Time Operator Physiological Monitoring to Drive Human-Robot Interaction (HRI) Design

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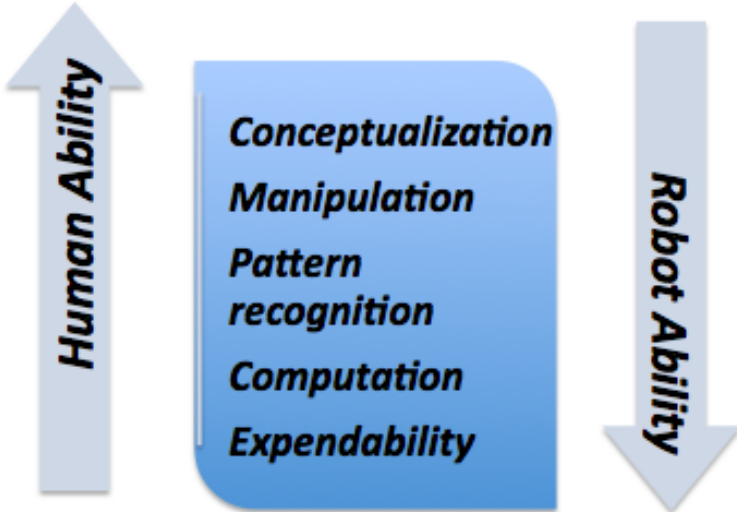


Background

Shared work spaces

Shared or dependent tasks

Shared “mental models”



Shared situation awareness

Affective awareness

Kinetic actions

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Limitations

- **The capabilities of robots are constrained by interaction limitations**
 - Effectiveness of automation is dependent on human control capabilities
 - Robot performance is often dictated by operator skill
 - Interaction is largely dictated by interface design



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Art vs. Science

- **Interface design is currently more of an art than a science**
 - Often based on engineering principles and robot functionality
 - Designers depend on user adaptability
 - Significant training time is currently required



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Solution

- **Interfaces must account for dynamic changes in interaction parameters**
 - Human/Robot/Mission parameters
 - Environment/Dispositions/SOPs/ROEs
- **Effective human-robot team interaction must optimize task allocation**
 - Exploit strengths and capabilities of humans and machines
 - Compensate for limitations of humans and machines



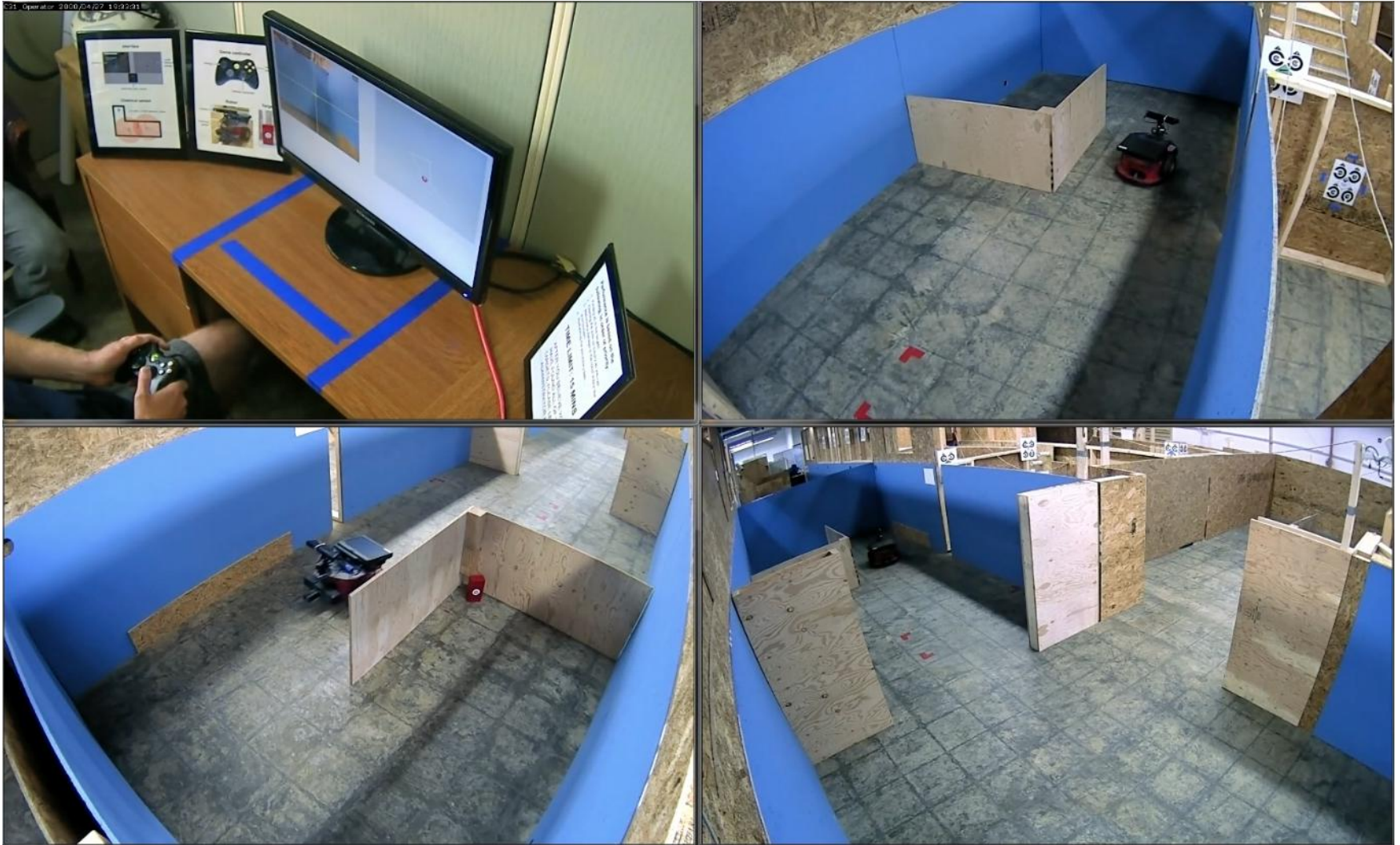
Efforts in HRI



- **DRC Evaluation**
- **Dynamic Robot Operator Interface Design (DROID) Assessment, Guidance, and Engineering Tool (AGENT)**



Primary Task

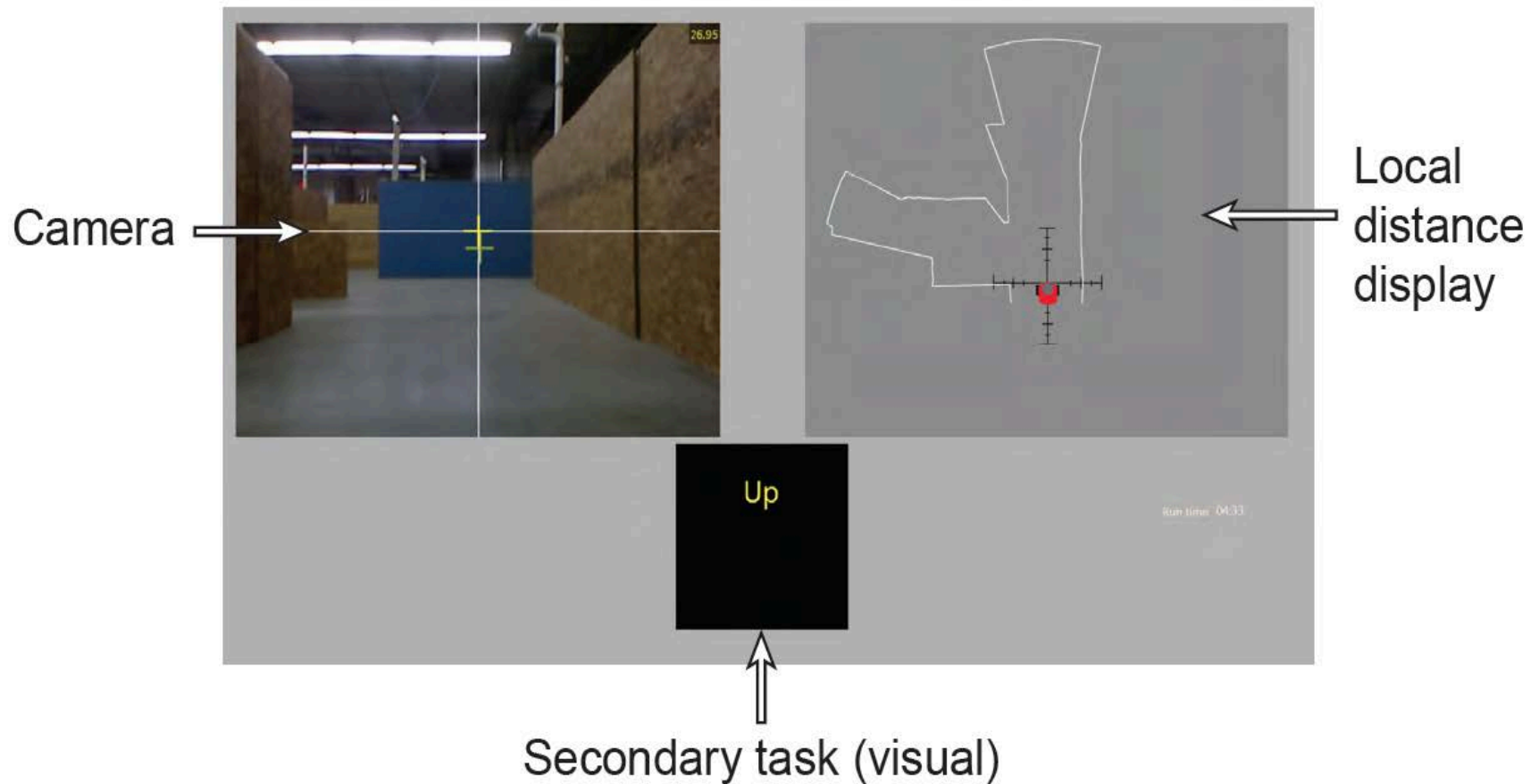


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Secondary Task

Interface

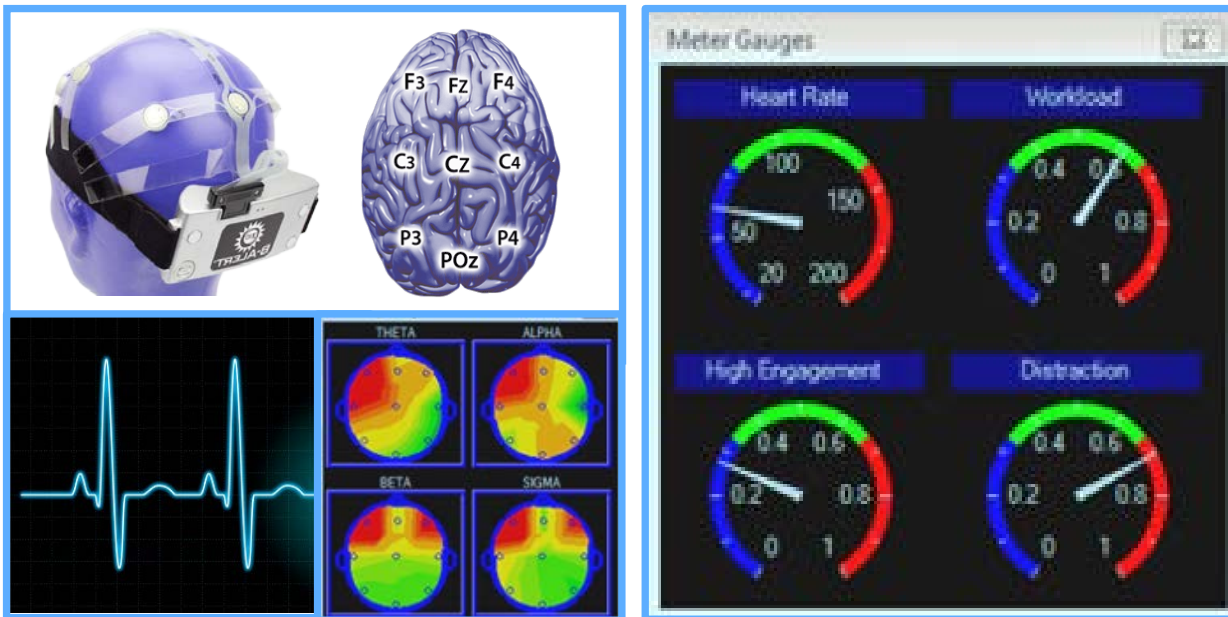


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Physiological Metrics

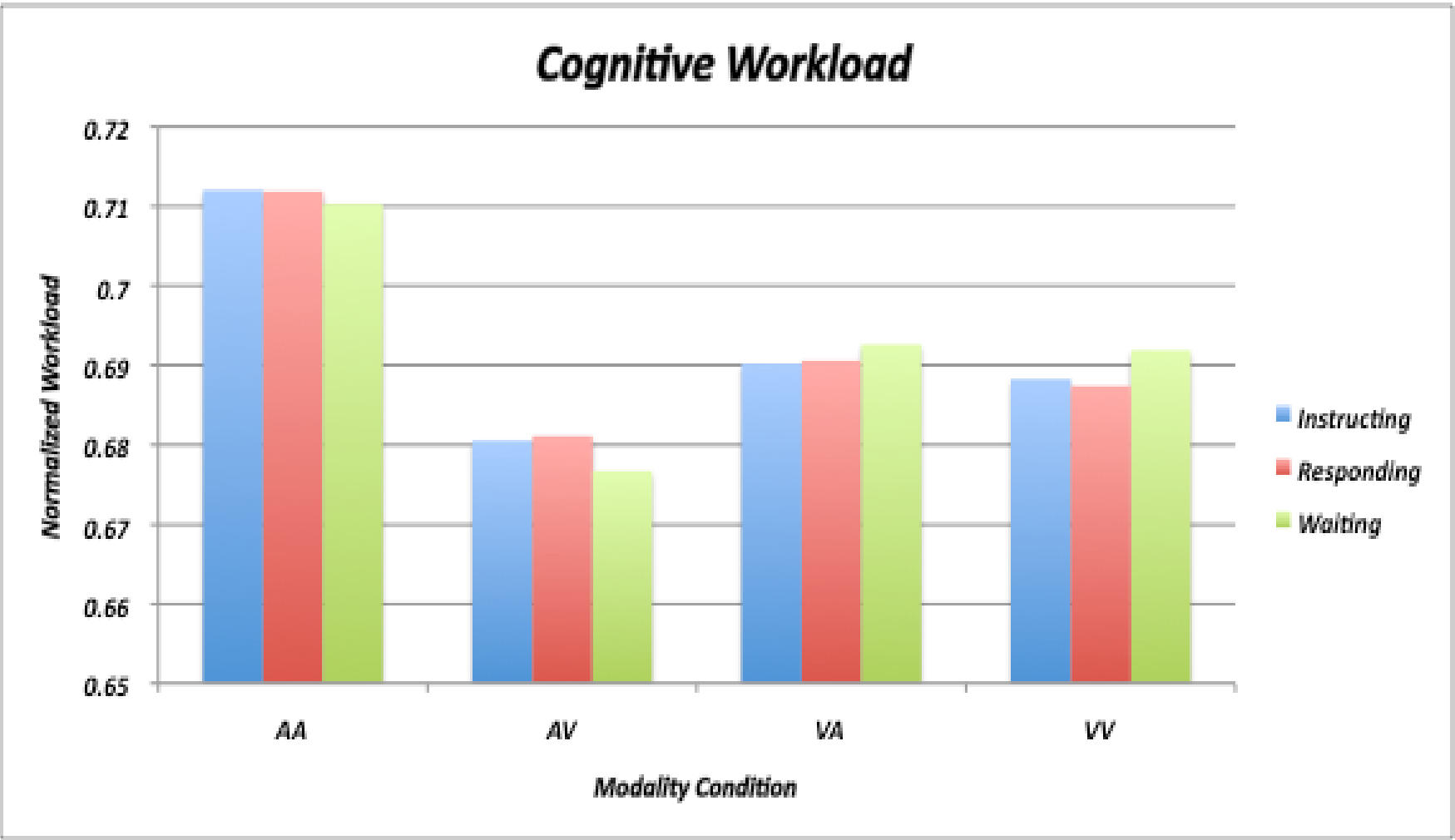
- **Provide objective assessment of operator state**
 - Cognitive and affective state detection
 - Verbal vs Spatial working memory load
- **Can be empirically correlated to performance metrics**
 - Insight into underlying cognitive/ psychomotor/ affective processes



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Findings



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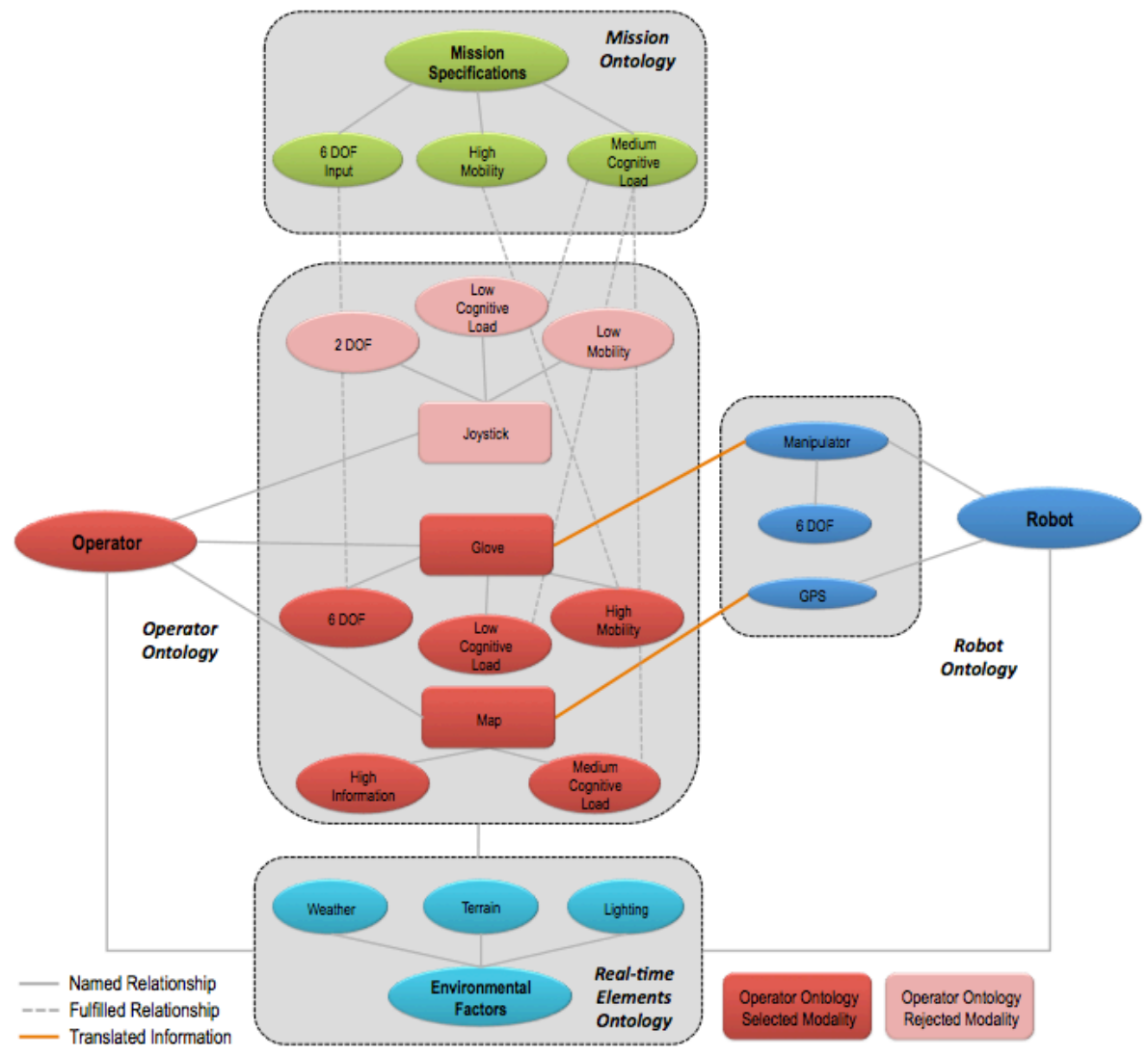


Adaptable Interfaces

- Support modularity and redundancy
- Customizable to specific mission, operator, and robot configurations
- Able to be reconfigured on the fly
- Automatically reconfigure in response to:
 - Operator state
 - Robot state
 - Environmental factors



HRI Design Ontology

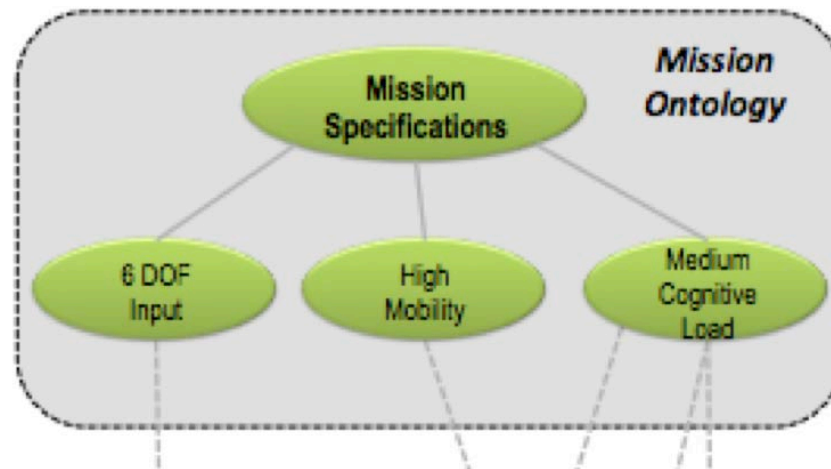


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Design Ontology (Mission)

- **Ontology relates concepts within underlying taxonomy**
 - Smart agent software architecture, underlying database and ontology to support automated HRI design guidance
 - Formulate ontologies to allow analysis using an autonomous reasoning agent
 - Set of relationships are of particular importance for analysis
 - Based on scientifically-grounded design principles and validated assessment metrics

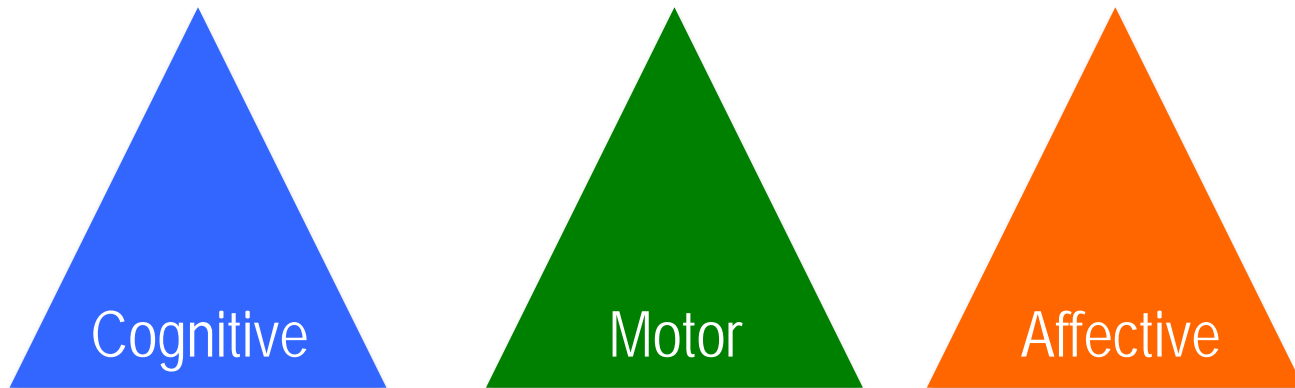


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Goal

- **Based on Multi-disciplinary HRI design process**
 - Involve stakeholders early in design process
 - Leverage strengths/weaknesses of humans and robots
 - Act as a translator between humans and robots
 - Mission-centric approach
 - Multi-modal and adaptive interfaces



Taxonomy of Human and Robot Skills

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Take Home

- **HRI should be considered from the beginning influencing robotic design**
- **Empirically-based methodology is needed**
- **Operator physiological monitoring can provide objective and quantifiable data to drive HRI design and assessment**
- **Real-time physiological measures can be used to drive adaptive interfaces**



Questions?